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(54) Chemical vapor deposition apparatus and method for exclusion of deposition and contamination from the backside and periphery of the wafers

(57) A platen supports a wafer during the deposition of tungsten, metal nitrides, other metals, and silicides in a chemical vapor deposition reactor. A deposition control gas that includes a suitable inert gas such as argon or a mixture of inert and reactant gases such as argon and hydrogen is introduced through a restrictive opening into an ambient in the reactor. An exclusion guard aligned with the platen has an extension extending over a front-

side peripheral region of the wafer. Deposition control gas is introduced under the exclusion guard extension and exits through a restrictive opening between the exclusion guard extension and a wafer frontside peripheral region. The restrictive opening provides a uniform pressure of deposition control gas at the edge and frontside of the wafer to prevent deposition on the wafer edge and backside.

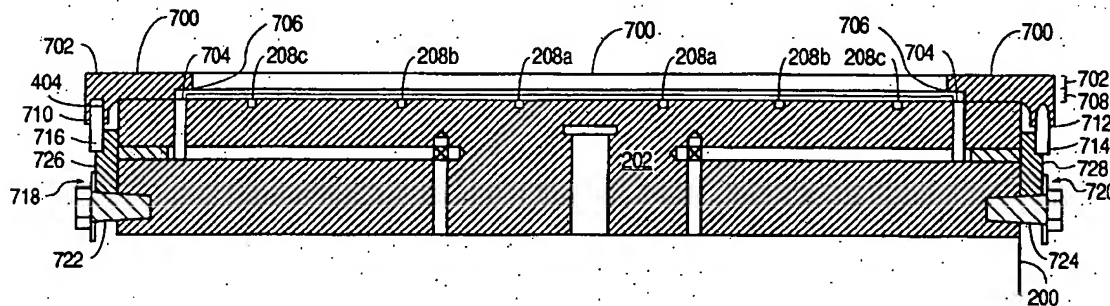


FIG. 7

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## Description

### CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part of copending and commonly assigned and copending Application Serial No. 08/294,514, filed August 23, 1994; which is a continuation-in-part of Application Serial Number 08/007,457, filed January 22, 1993, now U.S. Patent No. 5,374,594; which is a division of Application Serial No. 07/554,225, filed July 16, 1990, now U.S. Patent No. 5,230,741. These prior applications are incorporated herein in their entirety by reference thereto.

### BACKGROUND OF THE INVENTION

#### Field of the Invention

This invention relates to semiconductor processing, and more particularly to the protection of the backsides and edges of wafers during chemical vapor deposition.

#### Description of Related Art

Chemical vapor deposition ("CVD") is a gas reaction process commonly used in the semiconductor industry to form thin layers of material known as films over an integrated circuit substrate. The CVD process is based on the thermal, plasma, or thermal and plasma decomposition and reaction of selected gases. The most widely used CVD films are silicon dioxide, silicon nitride, and polysilicon, although a wide variety of CVD films suitable for insulators and dielectrics, semiconductors, conductors, superconductors, and magnetics are well known.

Particulate contamination of CVD films must be avoided. A particularly troublesome source of particulates in the chemical vapor deposition of metals and other conductors such as tungsten, tungsten silicide, and titanium nitride is the film that forms on the edge and backside of the wafer under certain conditions. For example, if the wafer edge and backside are unprotected or inadequately protected during deposition, a partial coating of the CVD material forms on the wafer edge and backside, respectively. This partial coating tends to peel and flake easily for some types of materials, introducing particulates into the chamber during deposition and subsequent handling steps.

Many approaches have been developed for addressing the problem of material deposition on the wafer backside. In one approach, the material is permitted to form on the backside, but then is removed immediately following the deposition step using an in-situ plasma etch. This approach entails additional process steps and requires additional equipment capabilities, and also affects the flatness of the wafer. In another approach, the wafer is clamped onto a substrate holder in an attempt to seal and isolate the backside region from the CVD gas. An adequate seal tends to be difficult to achieve in practice, and the mechanical motion between

the clamp and the wafer itself causes particulates. Yet another approach is disclosed in United States Patent No. 4,817,558, issued April 4, 1989 to Itoh. A substrate support member having the form of a cylinder is provided with a flat bearing surface on which the substrate rests. Three pins protrude from the peripheral edge portion of the bearing surface. The sidewalls of the substrate are insulated from the reactive gases by a cover, which is further provided with a lifted and bent region that surrounds the substrate at the level of the substrate. The lifted and bent region is said to trap the reactive gas on the lateral face of the wafer, thereby preventing a film from being deposited on the wafer backside.

The problem of edge and backside deposition is exacerbated by recent trends in the semiconductor industry toward more full utilization of the wafer surface area. The industry demands that material deposition conform to stated specifications over a major portion of the surface area of the wafer. Factors specified include uniformity and quality. Typically a portion of the frontside periphery of the wafer is excused from compliance with the specification because of wafer handling requirements. For example, for a 200 mm wafer, which is known in the industry as an "eight inch" wafer, the outside 6 mm of radius typically has been excused from compliance with the deposition standard, which results in an effective usable wafer diameter of 188 mm. However, recent supply problems in the industry due to capacity limitations have resulted in some manufacturers seeking greater utilization of the wafer surface area. For example, interest has been expressed in having an effective usable wafer diameter of at least 194 mm. Accordingly, methods and apparatus for chemical vapor deposition that permit an effective usable wafer diameter of nearly the full wafer diameter while preventing unwanted edge and backside deposition are desirable.

### SUMMARY OF THE INVENTION

Advantageously, the present invention eliminates undesirable deposition of material on the wafer backside and edge while maintaining good temperature uniformity and material deposition uniformity across the frontside deposition surface of the wafer. In some embodiments, material deposition uniformity is maintained nearly out to the edge of the wafer.

In one embodiment, an apparatus in accordance with the present invention comprises a wafer-supporting body disposed in a chamber of a chemical vapor deposition ("CVD") reactor. An exclusion body also disposed in the chamber is aligned with the support body, and includes a portion projecting over a frontside peripheral region of the wafer. When in position during wafer processing, the projecting portion is uniformly spaced from the wafer frontside peripheral region to form a uniformly restrictive passage connecting a first volume of the chamber proximate the wafer frontside deposition surface to a second volume proximate the wafer edge. The first volume communicates with a source of process

gas, and the second volume communicates with a source of deposition control gas. In a variation, the restrictive passage is spaced as close to the wafer front-side periphery as wafer and thermal expansion tolerances permit.

In a further apparatus embodiment, the exclusion body is provided with a venting region uniformly spaced from and encircling the exclusion body projecting portion. The venting region communicates with a source of venting gas for creating a venturi effect to draw the process gas toward the projecting portion when in place during wafer processing. In a variation, the venting region communicates with the second chamber, the venting gas being the same gas as the deposition control gas. In a further variation, the exclusion body is a single piece in which the venting region comprises a plurality of orifices through the exclusion body. In a further variation, the venting region contributes a reactant gas component to the first volume to improve deposition uniformity.

Another embodiment of the present invention is a method for performing chemical vapor deposition in a chamber of a chemical vapor deposition ("CVD") reactor. The method comprises supporting a wafer on a supporting body disposed in the CVD chamber, aligning an exclusion body disposed in the chamber with the support body, and uniformly spacing a projecting portion of the exclusion body from a frontside peripheral region of the wafer to form a restrictive passage connecting a first volume of the chamber proximate the wafer frontside deposition surface to a second volume proximate the wafer edge. The method further comprises providing a process gas to the first volume, and providing a deposition control gas to the second volume at a pressure equal to or greater than the pressure of the process gas. In a variation, the restrictive passage is as small as wafer and thermal expansion tolerances permit.

A further method embodiment comprises venting a gas uniformly around the first volume to create a venturi effect that draws the process gas toward the projecting portion during wafer processing. In a variation, the venting gas is the same gas as the deposition control gas.

#### BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings, in which like reference numerals refer to like parts,

Figure 1 is a cross-sectional view of a process chamber for a chemical vapor deposition system, as viewed from above;

Figure 2 is a cross-sectional view of the process chamber of Figure 1 illustrating exclusion guards and an exclusion guard lift assembly;

Figure 3 is a cross-sectional view of the process chamber of Figure 1, as viewed from a side;

Figure 4 is a top plan view of a platen illustrative of one embodiment of the platens shown in Figure 3;

Figure 5 is a cross sectional view of the platen of Figure 4;

Figure 6 is a view through a cross-section of a portion of the platen of Figure 4;

Figure 7 is a cross-sectional view of an exclusion guard embodiment in combination with a platen;

Figure 8 is an exploded partial cross-sectional view of the exclusion guard and platen shown in Figure 7;

Figure 9 is an exploded cross-sectional view of another exclusion guard embodiment similar to the exclusion guard of Figure 8 but modified to include a region for venting deposition control gas during wafer processing;

Figure 10 is a bottom view of another exclusion guard embodiment similar to the type shown in Figure 9;

Figure 11 is a partial cross-sectional view of the exclusion guard of Figure 10 shown mounted on a platen;

Figure 12 is a partial cross-sectional view of another exclusion guard embodiment in combination with a platen; and

Figure 13 is an isometric view of a centering station.

#### DESCRIPTION OF THE PREFERRED EMBODIMENT

An illustrative reaction chamber of a high pressure chemical vapor deposition ("CVD") apparatus is shown in Figure 1 from a top cross sectional view, cross sectioned directly above wafer transport mechanism 10 in an "up" position. The process chamber 2 communicates with a load lock chamber 1, from which wafers to be processed are introduced into the process chamber 2, and into which processed wafers are received from the process chamber 2. Chamber gases are exhausted through vent ports 6a-6f. A shaft opening 7 is located adjacent to vent ports 6a-6f. The system for moving wafers from station to station in the process chamber 2 includes pin lift platforms 8a-8c and wafer transport mechanism 10. Platens 14a-14e are not drawn to scale so that other features may be more readily apparent.

Figure 2 is a top cross sectional view of load lock chamber 1 and process chamber 2 illustrating the employment of an exclusion guard lift assembly 420 suitable for exclusion guarding or unguarding of the wafer process stations 4a-4e in conjunction with exclusion guards 441-445. A circular exclusion guard lift plate 422 is provided with six open regions 430-435 associated

with a load/unload station 5 and the five wafer process stations 4a-4e, respectively. Cutout regions 431-435, which are associated with the process stations 4a-4e, are of a diameter just greater than the diameter of the platens 14a-14e but just less than the outside diameter of the exclusion guards 441-445, and are designed to engage respectively the five exclusion guards 441-445. In process stations 4a-4e designed for 150 mm wafers, the regions 431-435 are semi-circular. In process stations 4a-4e designed for 200 mm wafers (not shown), the regions 431-435 are circular. The five exclusion guards 441-445 generally represent the exclusion guards discussed below. Cutout regions 431-435, exclusion guards 441-445, and process stations 4a-4e are not drawn to scale so that other features may be more readily apparent.

Typically, all of the process stations 4a-4e are either exclusion guarded or unguarded, although the process stations 4a-4e may be variously exclusion guarded or unguarded as desired merely by mounting or omitting respective ones of the corresponding exclusion guards 441-445. The exclusion guards 441-445 are engaged by the exclusion guard lift plate 422 in any suitable manner. For example, in Figure 2, the exclusion guards 441-445 are respectively aligned with cutout regions 431-435 and are merely contacted and lifted by the upper surface of the exclusion guard lift plate 422 as the exclusion guard lift plate 422 in conjunction with exclusion guard lift assembly 420 and a spindle lift/rotation mechanism (not shown) rises above the platens 14a-14e (Figure 3). The spindle lift/rotation mechanism is described in U.S. Patent Number 5,238,499, by Van de Ven et al., which is hereby incorporated by reference in its entirety. Note that the exclusion guards 441-445 are accessible for cleaning and changing merely by removing the top of the process chamber 2. Note also that no exclusion guard is mounted to the exclusion guard lift plate 422 at cutout region 430, which is associated with the load/unload station 5.

In Figure 3, wafer process stations 4b, 4c, and 4d are visible in more detail in a side view of the high pressure CVD reaction chamber. Process stations 4b-4d are not drawn to scale so that other features may be more readily apparent. Process station 4c, for example, includes a dispersion head 12c for introducing a process gas or gas mixture over a wafer to be processed; the platen 14c for supporting the wafer to be processed; a pedestal base 16c, which includes a heater for heating platen 14c and indirectly supplying heat to the wafer to be processed; and pin lift platform 8b, which is associated with pins 20c, 21c and 22c (hidden) for lifting and lowering the wafer to be processed in coordination with activation of the wafer transport mechanism 10. Similarly, process station 4b includes gas dispersion head 12b, platen 14b, pedestal base 16b, and pin lift platform 8a in association with pins 20b, 21b and 22b. Similarly, process station 4d includes gas dispersion head 12d, platen 14d, pedestal base 16d, and pin lift platform 8b in association with pins 20d, 21d and 22d (hidden). Also shown in Figure 3 are a vacuum exhaust port 24, a spin-

dle lift/rotation mechanism 26, and a pin lift mechanism 28, the designs of which are well known in the art. Process stations 4a and 4e are preferably similar to process stations 4b-4d. The assembly of the pedestal bases 16a-16e to platens 14a-14e, respectively and the composition of each are fully described in U.S. Patent Number 5,238,499 and in U.S. Patent Number 5,230,741, by van de Ven et. al. U.S. Patent Number 5,230,741 is also hereby incorporated by reference in its entirety.

The exclusion guard lift assembly 420 is mounted within process chamber 2 as shown in Figure 3. Suitable approaches for coupling the exclusion guard lift assembly 420 in vertical movement with the wafer transport mechanism 10 (Figure 1), while allowing the exclusion guard lift mechanism to be rotationally static relative to the process stations 4a-4e during rotation of the wafer transport mechanism 10, are described in conjunction with a shroud lift assembly in the aforementioned U.S. Patent Number 5,238,499.

The aforementioned U.S. Patent Number 5,238,499 additionally describes in detail the physical configuration and operation involved in transporting, guarding, and unguarding of the wafers to be processed. Briefly, the wafer to be processed is introduced into the process chamber 2 from the load lock chamber 1 at a reduced pressure such as 40 Torr, and is received at an empty load/unload station 5 and lowered onto raised lift pins 20f, 21f and 22f. By coordinating the rotation of wafer transport mechanism 10 and the raising and lowering of the lift pins 20a-20f, 21a-21f, and 22a-22f, the wafers are transported to successive ones of the stations 4a-4e and 5. As the wafer transport mechanism 10 rises toward a level suitable for engaging wafers at the stations 4a-4e and 5, the exclusion guard lift plate 422 also rises, thereby lifting exclusion guards 441-445 to clear the space above the process stations 4a-4e for transport of the wafers. As the wafer transport mechanism 10 lowers from the level suitable for engaging wafers at the stations 4a-4e and 5, the exclusion guard lift assembly 420 also lowers. Note that the motion of lift pins 20a-20f and 22a-22f follows the upward motion movement of transport mechanism 10 and exclusion guard lift assembly 420, and precedes the downward movement of transport mechanism 10 and exclusion guard lift assembly 420. When the wafer at the load/lock station 5 is fully processed, it is removed into the load lock chamber 1.

When the pins 20a-20f, 21a-21f, and 22a-22f at the stations 4a-4e and 5 (Figures 2 and 3) lower, the wafers to be processed are deposited on respective platens 14a-14e under respective gas dispersion heads 12a-12e. Once the wafers are deposited on the respective platens 14a-14e, the wafers are preferably secured to the respective platens 14a-14e. Various techniques for securing the wafers to a wafer contact on a respective platen may be used. One preferable technique uses a vacuum chuck. The term "vacuum" is used herein in a relative sense to mean a pressure less than another pressure, e.g. the pressure in the vacuum chucks at the respective process stations 4a-4e relative to a pressure

in the process chamber 2. A suitable vacuum for the vacuum chucks of the respective process stations 4a-4e during deposition operations is, for example, a pressure differential of 10 Torr or greater relative to the process chamber pressure.

When the exclusion guard lift assembly 420 is lowered, the exclusion guards 441-445 are deposited on the top of the platens 14a-14e at the respective process stations 4a-4e, thereby exclusion guarding the wafers. The platens 14a-14e are representative of, for example, platen 200 (Figures 5 through 9), platen 1100 (Figure 11), and platen 1206 (Figure 12). Various measures may be taken to retain the exclusion guards 441-445 in place. For example, Figure 2 shows an approach in which the exclusion guards 441-445 are made to be of a suitable weight so that gravity acts to retain the exclusion guards in place.

The physical configuration and operation of the high pressure CVD apparatus of Figures 1, 2, and 3 and the elements thereof, including pedestal base suitable for pedestal bases 16b, 16c and 16d, are set forth in further detail in the aforementioned U.S. Patent Number 5,230,741.

An illustrative platen 200 that is suitable for 200 mm wafers and incorporates a vacuum chuck is shown in Figures 4, 5, and 6. The major component of the platen 200 is a circular block 202 of aluminum or other suitable material such as stainless steel. As viewed from the top (Figure 4), the upper surface of the platen block 202 is provided with 8 vacuum holes 205a-205h from which radial vacuum grooves 206a-206h extend. The end of vacuum line 204, which appears as a central blind hole, lies 0.25 inches below the top surface of platen block 202. The top of vacuum line 204 is 0.32 inches in diameter, and decreases, approximately 0.38 inches from the top of vacuum line 204, to a diameter of 0.25 inches. Vacuum line 204 extends through the bottom of platen block 202. The radial grooves 206a-206h are rectangular in cross section, although other shapes are suitable as well, and are 0.118 inches deep and 0.128 inches wide. The eight radial grooves 206a-206h are regularly disposed at forty-five degree angles from one another. Radial grooves 206a-206h intersect concentric annular vacuum grooves 208a, 208b, and 208c. Concentric annular vacuum grooves 208a, 208b, and 208c in turn intersect radial vacuum grooves 209a-209q. Grooves 208a-208c and 209a-209q are rectangular in cross section and measure 0.118 inches deep and 0.128 inches wide, like the radial grooves 206a-206h. The outer radius of the inner annular groove 208a is 1.485 inches, the outer radius of the middle annular groove 208b is 2.465 inches, and the outer radius of the outer annular groove 208c is 3.445 inches. The outer radius of annular groove 208c may be increased if desired to contact a wafer backside region contiguous to the edge of a wafer placed on the wafer contact, i.e. a portion of the top surface of platen 200 beneath the wafer positioned on platen 200. Although the diametrical dimensions referred to above are suitable for processing a 200 mm diameter wafer,

commonly known as an "eight inch" wafer, they may be scaled so as to facilitate the processing of wafers with a variety of diameters.

Referring to Figure 5, a tube (not shown) is fastened to vacuum line 204 by a suitable fastener and the combined force exerted through the vacuum grooves 206a-206h, 208a-208c, and 209a-209q is sufficient to uniformly and tightly retain a wafer on the platen 200 during processing.

Another well known technique uses electrostatic attraction to secure the wafers to the platens 14a-14e. An electrostatic clamping technique is described in U.S. Patent Number 4,184,188 by Briglia, which is hereby incorporated by reference in its entirety.

An additional technique of securing a wafer to the platens 14a-14e involves placing a wafer on a platen, such as platen 202 without vacuum holes and grooves, and allowing gravity to retain the wafer in place. However, the excellent heat transfer (discussed below) between the wafer and platen achieved with other techniques due to uniform, tight retention, such as the vacuum chuck technique discussed above, is somewhat reduced.

In order to stimulate the deposition of material onto the wafer being processed, heat is provided to the wafer. One method of providing heat to the wafer involves heating each of the respective platens 14a-14e which transfers heat to the wafers sitting respectively thereon. Referring to illustrative platen 200 in Figure 5, a spiral groove 232 is incorporated into the bottom of platen block 202 to accommodate a resistive heating element, both of which are fully described in the aforementioned U.S. Patent Number 5,230,741. In a variation of the attachment technique described in that patent, the resistive heating element is made of fewer turns and the spiral groove is modified accordingly, but the resistive heating element is welded to the platen.

In some deposition operations, and particularly in the CVD deposition of metals and metal compounds such as tungsten, titanium nitride, and silicides, one may wish to exclude deposition of material from the wafer backside and from the wafer edge. One method of achieving this result involves introducing deposition control gas near an edge of a wafer positioned on a platen from within each of the respective platens 14a-14e. The term "deposition control" gas means a gas that assists in controlling or eliminating chemical vapor deposition of material on certain portions of the wafer. For example, in one embodiment the deposition control gas contains chemicals, such as hydrogen, that enhance deposition near areas of a wafer such as the frontside peripheral region of a wafer exposed to a mixture of the deposition control gas and process gas, while excluding process gas from other portions such as the backside and edge to prevent unwanted deposition thereon. Since the edge of a wafer may have multiple planar and non-planar, beveled and non-beveled edge surfaces, the term "edge" is intended to encompass all non-frontside, non-backside surfaces.

Referring to the illustrative platen 200 in Figures 4 through 6, integral gas lines and gas grooves are incorporated in platen 200 to facilitate the introduction of deposition control gas from within the platen. Dimensions are given below for various features of a version of the platen 200 that accepts 200 mm wafers, and are room temperature or "cold" dimensions. It will be appreciated that the dimensions described below are illustrative, and other dimensions may be selected to meet particular design criteria such as different gas and vacuum pressures, process parameters, process chamber sizes, and wafer sizes.

An annular gas groove 210 is provided within a peripheral region 211 of the top surface of platen block 202 outside of the outermost annular vacuum groove 208c. The annular groove 210 is rectangular in cross section, measuring 0.093 inches wide and 0.50 inches deep. While the outside diameter preferably exceeds the radius of the wafer being processed, the inside diameter may or may not exceed the radius of the wafer. Placing the opening of gas groove 210 beyond the edge of the wafer being processed provides a full contact surface area between platen block 202 and the wafer, thereby ensuring thermal uniformity in the wafer. However, permitting the wafer to somewhat overhang the gas groove 210 provides somewhat better process gas exclusion without sacrificing thermal uniformity. In one embodiment for processing a 200 mm (7.87 inch) wafer, the inside diameter is 7.750 inches and the outside diameter is 7.936 inches. In this embodiment, a wafer being processed overhangs into the gas groove 210 about 0.06 inches under cold conditions. The overhang is somewhat less during processing, when the platen 200 is heated.

The gas groove 210 intersects a network of radial gas lines 212a-212j for distributing gas to the backside of the wafer to be processed. Radial gas lines 212a-212j are shown in hidden lines in Figure 4, and selectively in cross section in Figure 5. Lines 212a-212j are radially distributed in the platen block 202 at 36 degree intervals. Each of the bores for the ten gas lines 212a-212j is 0.156 inches in diameter, begins in the vertical edge of the platen block 202 at a distance of 0.35 inches from the top surface of the platen block 202 to the bore centerline, is parallel to the top surface of the platen block 202, and extends sufficiently into the platen block 202 to intersect a respective one of the ten vertical bores for gas lines 216a-216j, which extend from the bottom surface of the platen block 202 (Figure 5). The gas lines 212a-212j are plugged by respective plugs 218a-218j (see, e.g., plugs 218d and 218i in Figure 5), which extend 0.25 inches from the outside vertical edge of the platen block 202 to just short of the gas groove 210. The plugs 218a-218j are press fitted into gas grooves 212a-212j. The diameter of the bores for gas lines 216a-216j is 0.156 inches. The total thickness of the platen 200 is 1.694 inches with an outside diameter of 9 inches.

A second network is formed of radial gas lines 214a-214c, which are bored in the platen block 202 for distributing backside gas to holes 107a-107c. Holes 107a-107c

accommodate wafer lift pins such as 20c, 21c and 22c shown in Figure 2. Holes 107a-107c, respective index holes 224a-224c (Figure 6), and index sleeves (not shown) are fully described in the aforementioned U.S. Patent Number 5,230,741. Radial gas lines 214a-214c are shown in hidden lines in Figure 4, and selectively in cross section in Figure 6. Each of the bores for the three gas lines 214a-214c is 0.156 inches in diameter, begins in the vertical edge of the platen block 202 a distance 0.76 inches from the top surface of the platen block 202 to the bore centerline, is parallel to the top surface of the platen block 202, and extends sufficiently into the platen block 202 to intersect a respective one of the three vertical bores for gas lines 220a-220c, which extend from the bottom surface of the platen block 202 (Figure 6). The gas lines 214a-214c are plugged by respective plugs 222a-222c (see, e.g., plug 222a in Figure 6), which extend 0.25 inches from the outside vertical edge of the platen block 202 to just short of the respective gas lines 220a-220c. The plugs 222a-222c are press fitted into gas lines 214a-214c. The diameter of the bores for gas lines 220a-220c is 0.063 inches.

Holes 107a-107c, which accommodate wafer lift pins such as 20c, 21c and 22c shown in Figure 2, are 0.187 inches in diameter and pass through platen block 202. Toward the bottom surface of the platen block 202, holes 107a-107c merge into, respectively, index holes 224a-224c, which are 0.312 inches in diameter and provided to receive respective index sleeves (not shown) of a base pedestal such as base pedestals 16b, 16c, or 16d (Figure 3). The center axes of holes 107a-107c are offset from, respectively, the center axes of holes 224a-224c, to accommodate the eccentricity between holes 107a-107c and index sleeves (not shown).

The dimensions of a platen suitable for accommodating 150 mm wafers, commonly known as "six" inch wafers, is described in the aforementioned U.S. Patent Number 5,230,741 with the exception that the inside diameter of gas groove 210 in U.S. Patent Number 5,230,741 is preferably increased to 5.790 inches and the outside diameter is preferably increased to 6.00 inches. The width of the annular groove 210 in this embodiment is 0.105 inches. A six wafer which has a diameter of 5.91 inches overhangs into the gas groove 210 about 0.06 inches. It will be appreciated that these dimensions are illustrative.

To further appreciate the function of the deposition control gas when introduced at the platen stations 4a-4e in coordination with the introduction of a process gas at the gas dispersion heads 12a-12e, consider the illustrative platen 200 of Figure 4 through Figure 6. In this embodiment, the deposition control gas is introduced through annular groove 210 and eventually vents into the process chamber 2 (Figure 3). The volume of deposition control gas furnished to the gas groove 210 is determined based on the desired rate of venting and the effect of the deposition control gas on the wafer frontside deposition. In the process chamber 2, the deposition control gas mixes with the process gas and is exhausted from



the process chamber 2 through the vent ports 426a-426f (Figure 2) and 6a-6f (Figure 1). The deposition control gas enters the lifting pin holes 107a-107c to prevent the process gas from reaching the area around the lifting pins and the wafer backside through the lift pin holes 107a-107c.

Prior to entering the various channels in the platen 200, the deposition control gas is introduced into the interior volume of a pedestal base such as pedestal base 16b. As shown in Figure 4 through Figure 6, the deposition control gas enters gas lines 216a-216j from the interior volume under the platen block 202 and flows to groove 210 through gas lines 212a-212j. The deposition control gas also enters gas lines 220a-220c, from which it flows to lift pin holes 107a-107c through respective gas lines 214a-214c. As gas lines 220a-220c are smaller than gas lines 216a-216j, the flow through them is relatively restricted. The deposition control gas is heated both within the volume under the platen block 202 and as it flows through the various gas lines, as described in the aforementioned U.S. Patent Number 5,230,741.

A variety of materials may be deposited using various process gases with suitably selected deposition control gases. For example, to deposit a tungsten film with the apparatus of Figures 1, 2, and 3, the product reactant  $WF_6$  is used under the reactant conditions of  $H_2$  and Ar. The  $WF_6$  and  $H_2$  gases are the reactant components of the process. A suitable deposition control gas is argon, hydrogen, or a mixture of argon and hydrogen. The various constituent gases are delivered to and mixed in a suitable manifold, as is well known in the art.

Silane, or  $SiH_4$ , is also used at the process station 4a. Initially, a mixture of  $SiH_4$ ,  $H_2$  and Ar is used to deposit a thin protective amorphous silicon film, which also provides a nucleation function under certain circumstances. Then, a mixture of  $WF_6$ ,  $SiH_4$ ,  $H_2$  and Ar is used to deposit an initial tungsten film. The  $WF_6$  consumes the thin amorphous silicon film.

Uniformity of deposition near the frontside periphery of the wafers being processed is further improved by including a reactive component of the process gas in the deposition control gas. In the example of the preceding paragraph in which the reactant gases are  $WF_6$  (product reactant) and  $H_2$  and the carrier gas is Ar or  $N_2$  or a mixture of Ar and  $N_2$ , improved uniformity of edge deposition is obtained by mixing the reactive component  $H_2$  with Ar or  $N_2$  or a mixture of Ar and  $N_2$  to obtain the deposition control gas. The proper proportion of reactive component to inert gas is determined empirically. The process gas mixture (e.g.  $WF_6+H_2+Ar$  flow ratios and  $WF_6+H_2+Ar$  total flow) and deposition control gas mixture (e.g.  $H_2+Ar$  flow ratios and  $H_2+Ar$  total flow) are interactively combined and changed to produce the best frontside wafer uniformity while maintaining process gas exclusion from the wafer edge and backside.

In depositing other films, other process gases with different reactant components may be used. Suitable inert gases for use in the deposition control gas mixture include argon, nitrogen, and helium or any suitable com-

bination thereof. An inert gas is any gas that does not react adversely with the materials present in the process chamber 2 and in the gas distribution system, and that does not participate in the chemical reactions involved. Moreover, it is desirable that the thermal conductivity and heat capacity of the inert gas be sufficient to achieve good temperature uniformity across the wafers being processed.

Exclusion of process gas from the wafer backside and edge is assisted by the use of a structure such as an "exclusion guard" in combination with the use of the deposition control gas during processing. A generalized embodiment of an exclusion guard, which is made of any suitable material such as metal or ceramic (including, for example, alumina), is exclusion guard 700 shown in cross section in Figure 7. The exclusion guard 700 is shown in conjunction with platen 200, although other platen designs may be used as well. The wafer 402 is held in place on platen block 202 by the vacuum chuck. Exclusion guard 700 has a platform section 708 and an extension 704. The leading inside edge of extension 704 extends over the frontside periphery of wafer 402. The extension 704 is separated from the frontside of the wafer 402 by a restrictive opening 706.

Figure 8 illustrates an exploded partial cross sectional view of the generalized exclusion guard 700 of Figure 7. During processing, deposition control gas is introduced in platen block 202 as discussed above. Restrictive opening 706 serves to equalize the pressure in a plenum formed in part by gas groove 210 and the cavity between gas groove 210 and extension 704. As a result, deposition control gas flow, as indicated by the arrows in Figure 8, is uniform through the restrictive opening 706 over the entire wafer frontside periphery. This uniform deposition control gas flow denies process gas access to the edge and backside of the wafer 402, thereby preventing material deposition on these surfaces.

The flow rate of the deposition control gas through the restrictive opening 706 is related to the dimensions of restrictive opening 706. Where the restrictive opening 706 is extremely small, an extremely low flow rate through the restrictive opening is effective in denying process gas access to the edge and backside of the wafer 402 with a minimum overlap of the extension 704 over the wafer 402, which permits uniform material deposition on the frontside of wafer 402 to as close to the edge of wafer 402 as possible.

Where the flow rate is the primary exclusion mechanism, the principal factors are the area and length of the restrictive opening 706. The interference of process gas flow by deposition control gas venting from the restrictive opening 706 can be minimized by reducing the flow rate of the deposition control gas through the restrictive opening 706, although the flow rate preferable is maintained at a sufficient level to create a uniform pressure region underneath extension 704. In an embodiment for a 200 mm wafer where the restrictive opening has a width, i.e. the distance separating the extension 1004 and the frontside of the mounted wafer, of 0.50 mm

and where the distance the extension 704 extends over the frontside of wafer 402 is about 3.0 mm, for example, and assuming about 1200 sccm is furnished to the process station (no venturi holes), an illustrative suitable ratio of deposition control gas flow rate to restrictive opening area sufficient to create a uniform pressure region underneath extension 704 is therefor approximately 4 sccm per 1 mm<sup>2</sup>.

The tungsten exclusion effect is inversely proportional to the size of the restrictive opening, directly proportional to the extension overlap distance, and directly proportional to the deposition control gas flow rate. If one desires to relax the need for careful control of the size of the restrictive opening 706, the extension overlap distance may be increased. While increasing the extension overlap distance relaxes the need for careful control of the size of the restrictive opening 706, it adversely affects uniform material deposition at distances further from the edge of the wafer 402. If one desires to reduce the deposition control gas flow rate through the restrictive opening 706, the size of restrictive opening 706 may be decreased and/or the extension overlap distance may be increased.

Where an extremely small size of the restrictive opening 706 and an extremely low flow rate are the primary exclusion mechanism, the principal factor is the size of the restrictive opening 706, which is determined by the tolerances of the wafer and various system components as described in the context of the exclusion guard of Figure 10 and Figure 11.

Note that except for wafer 402 backside portions overlying the vacuum grooves 208a, 208b, 208c, and 206a-206h (hidden), and 209a-209q (hidden), as well as any portion of the wafer overhanging the deposition control gas channel 210, the backside of wafer 402 is in full contact with the top surface of the platen 200. This large contact facilitates uniform thermal transfer from the platen 200 to the entire wafer 402 backside, which may be further ensured by backfilling the various vacuum grooves with a thermal gas to a pressure less than the pressure on the frontside of the wafer 402. Uniform thermal distribution along the wafer 402 backside facilitates uniform thermal distribution along the wafer 402 frontside which enhances approximately uniform deposition of materials across the frontside of wafer 402.

To improve the extent of uniform material deposition on the wafer 402 frontside periphery, the deposition control gas preferably includes one or more reactive components of the process gas as discussed above. The reactive component in the deposition control gas enhances deposition at the wafer 402 periphery to compensate for any process gas flow interference in a region caused by the deposition control gas venting from restrictive opening 706 and the physical presence of a portion of the extension 704 extending over the wafer 402 into the flow pattern of the process gas. For example, when depositing W and using H<sub>2</sub> as the reactive component in the deposition control gas, the deposition rate of W (produced by reacting WF<sub>6</sub> with H<sub>2</sub>) varies proportion-

ately with the square root of the H<sub>2</sub> concentration, i.e. a four times increase in the quantity of H<sub>2</sub> increases the deposition rate of W by a factor of two. Therefore, to enhance the deposition of W by a factor of two at the frontside periphery of a wafer, the H<sub>2</sub> concentration is increased by a factor of four at the frontside periphery of the wafer. Note that a greater overall concentration of H<sub>2</sub> may be required in the deposition control gas to assure that an increase of four times reaches the wafer frontside periphery. Note also that when increasing a reactive component in the deposition control gas, for example H<sub>2</sub>, a reactive component in the process gas, for example WF<sub>6</sub>, is preferably supplied to sustain the kinetically possible deposition rate. Otherwise, the reaction may be "starved" in regions rich in H<sub>2</sub> and deficient in WF<sub>6</sub>.

The flow rate of the deposition control gas is inversely related to the quantity of reactive component present in the deposition control gas. Therefore, when the flow rate is reduced, the quantity of a reactive component (e.g. H<sub>2</sub>) may be increased to achieve the desired uniformity of deposition on the frontside of wafer 402, and *vice versa*.

In some processes a reduced flow of deposition control gas may not deliver sufficient reactive component(s) to the interference region to overcome perturbation of the process gas flow by the exclusion guard 700 and the dilution effect of the deposition control gas venting from the restrictive opening 706, so that the extent of uniform deposition may not be as great as desired. Providing orifices in an exclusion guard minimizes deposition control gas interference while preferably increasing the supply of reactive components to the wafer 402 frontside periphery. A generalized exclusion guard 900 that includes orifices, for example holes 902, and extension 903 is shown in Figure 9. The leading edge of the extension 903 has been modified to slope at a 30 degree angle to improve the flow of deposition control gas and process gas at the frontside periphery of wafer 402. Holes 902 extend from the top surface of exclusion guard 900 to a deposition control gas source. The total amount of deposition control gas entering the ambient of process chamber 2 equals the amount of deposition control gas flowing through restrictive opening 706 and holes 902. Therefore, the total amount of deposition control gas can be increased in the region of the process chamber 2 over the wafer frontside periphery without increasing the flow rate of deposition control gas through restrictive opening 706. The holes 902 should preferably vent a portion of the deposition control gas into the process chamber 2 (Figure 3) toward the outside edge of exclusion guard 900 to create a venturi effect to draw the process gas along the wafer frontside toward the leading edge of the extension 903 during wafer processing, even while some of the deposition control gas diffuses back toward the leading edge of the extension 903 to increase the supply of reactant gas components to the frontside periphery of wafer 402, thereby improving uniform wafer frontside deposition. While the ratio of Ar to H<sub>2</sub> in the deposition control gas is empirically determined, an illustrative suit-



able ratio is 1:5 for an embodiment in which the deposition control gas flow is the primary mechanism of process gas exclusion. Other orientations, including holes perpendicular to the top surface of exclusion guard 900 or slanting the holes at an angle in the direction of the wafer frontside center, may be suitable in some applications. The holes 902 may be manufactured by drilling through the top surface of exclusion guard 900 and into the cavity beneath extension 704. Alternatively (not shown), the holes 902 may be manufactured by drilling through the top surface of exclusion guard 900, through the platen 202, and into the gas groove 210.

While the dimensions of the exclusion guards 700 and 900 are not critical, they are selected in accordance with the dimensions of the wafer 402 and the flow capacity of the deposition control gas delivery system. When deposition is as near the edge of the wafer as possible is important, the spacing of the exclusion from the frontside wafer surface is important.

Figure 10 illustrates a bottom view of a particular exclusion guard 1000 having a minimum extension and a suitable array of orifices for obtaining a highly uniform deposition nearly out to the edge of the wafer being processed. The opening of holes 1002 shown as solid circles. There are 180 holes 1002 spaced 2 degrees apart with each hole having a diameter of 0.079 inches. An alignment hole 1004 and alignment slot 1006 are also shown. The outside edge of exclusion guard 1000 preferably has indentations 1008 and 1010 to accommodate adjacent exclusion guards in process chamber 2. The overall diameter of exclusion guard 900 is 9.67 inches, the inside diameter of extension 903 is 7.756 inches, and the extension outside diameter is 8.35 inches.

A cross-section view of the exclusion guard 1000 disposed on a platen 1100 is shown in Figure 11. The following dimensions of the exclusion guard 1000 are cold dimensions. Inside edge 1012 of the extension 1004 slopes at an angle of 30 degrees. The extension 1004 extends over and is spaced from the frontside periphery of the wafer being processed (not shown) to a degree depending on a number of factors, including wafer tolerances and placement accuracy. Holes 1002 slope at an angle of 45 degrees. The thickness of extension 1004 is 0.061 inches, the thickness of the platform section is 0.0405 inches (0.0305 inches is provided to raise extension 1004 above the wafer, and 0.010 inches is provided to account for the degree of depression of the periphery of the top surface of the platen 1100 relative to the interior of the top surface of the platen 1100), and the distance from the bottom of flange 404 to the bottom of platform section 708 is 0.149 inches. Extension transition surface 1014 slopes at an angle of 30 degrees.

When disposed on the platen 1100 on which a 200 mm wafer having a thickness of 0.725 mm (28.7 mils) is mounted, the width of the restrictive opening, or the separation distance between the extension 1004 and the frontside of the mounted wafer, is preferably about 0.0018 inches (0.050 mm). Because the wafer thickness

varies approximately  $\pm 0.025$  mm, the actual gap varies between approximately 0.025 mm to 0.077 mm.

Because of the extremely small width of the restrictive opening between the extension 1004 and the frontside of the mounted wafer, a very large percentage of the deposition control gas, approximately 99%, vents through the holes 1002. The flow rate through the restrictive opening for each process station 4a-4e is therefore only about 40 sccm (assuming 4 slm total deposition control gas flow), or a ratio of about 1.3 sccm per 1 mm<sup>2</sup>. The minimum length of the restrictive opening depends on wafer placement accuracy and a number of other factors. The wafer "edge" can intrude up to 0.56 mm in from a theoretical 100 mm wafer radius (200 mm wafer diameter), of which 0.46 mm is due to the beveled area of the wafer and 0.10 mm is due to wafer radius tolerance. The tungsten film preferably should end before reaching this 0.56 mm point to prevent tungsten deposition on the edge. In addition, the alumina exclusion guard expands by 0.20 mm more than the silicon wafer when heated to process temperatures. Hence, a 1.5 mm overlap of the guard to the wafer when cold translates into a 1.3 mm overlap at process temperatures. Finally, the film deposits due to diffusion to 0.40 mm underneath the extension 1004.

For a perfectly centered wafer, an exclusion guard extension overlap distance of 1.16 mm would be suitable, to account for 0.56 mm wafer error, 0.2 mm expansion mismatch, and 0.4 mm deposition under the exclusion guard. Typical system placement accuracy is on the order of  $\pm 0.5$  mm, so that a suitable extension overlap distance in practice is 1.66 mm. For a system placement accuracy of  $\pm 0.8$  mm, a suitable extension overlap distance in practice is 1.96 mm.

The deposited tungsten film reaches 90% of full thickness at a distance of 0.75 mm from the inside edge 1012 of the exclusion guard 1000. For example, an exclusion guard having a 1.5 mm extension overlap distance would result in a film that reaches 90% of full thickness at a distance of 2.25 mm from the edge of the wafer.

Illustratively, to achieve a tungsten deposition rate of 3400 Å/min, for example, with the chamber 2 of Figure 1 through Figure 3 using the exclusion ring 1000 of Figure 10, the various parameters are set to the following values: deposition temperature of 445 degrees C, operating pressure of 40 Torr (the pressure on the wafer being processed is somewhat greater than 40 Torr because the gas stream from the dispersion head impinges directly on the surface of the wafer), process gas flow to each of the dispersion heads 12a-12e on the order of 3-4 standard liters per minute, and deposition control gas flow to each of the process stations 4a-4e of preferably about 3-5 standard liters per minute, although the deposition control gas flow may be as high as about 3 standard liters per minute. The ratio of Ar to H<sub>2</sub> at the dispersion head is 9:10, and ratio of Ar to H<sub>2</sub> in the deposition control gas is 8:15.

Referring to Figure 12, another exclusion guard embodiment, exclusion guard 1200, is illustrated. Exclu-

sion guard 1200 is identical to exclusion guard 700 except that exclusion guard 1200 does not have a platform section. In order to elevate extension 1204 over the frontside periphery of wafer 402, platen 1206 includes integral, annular, elevated platform 1202. Platen 1206 differs from platen 200 only in the presence of platforms 1202. The complete discussion of exclusion guard 700 in conjunction with platen 200 is otherwise fully applicable. Additionally, orifices (not shown) such as holes may be drilled through exclusion guard 1200 and into a deposition control gas source as discussed in conjunction with Figure 9.

The respective exclusion guards of Figures 7, 9, and 12 may be modified to form split exclusion guards (not shown) i.e. an interior exclusion guard and an exterior exclusion guard separated by a channel. The interior exclusion guard extends over the frontside periphery of wafer 402 forming a restrictive opening to deposition control gas flow. The interior exclusion guard may be a continuous, independent exclusion guard or may be attached to the exterior exclusion guard using any suitable structure that provides minimal interference with the flow of deposition control gas through the channel. The channel also forms a restrictive opening and extends from the top surface of the respective exclusion guard to a deposition control gas source such as gas groove 210. The orientation of channels, the effect on deposition control gas flow, and material deposition on the frontside periphery of wafer 402 is the same as discussed above in conjunction with orifices 902 and 1002 in Figures 9, 10, and 11. The channels may be manufactured by drilling through the top surface of exclusion guard and into the cavity beneath the respective exclusion guard extensions.

If precise alignment accuracy is desired and is preferable when forming a restrictive opening of 0.50 mm or less between an exclusion guard and an edge of a wafer, the exclusion guards in Figures 7-12 may be provided with any suitable type and arrangement of alignment means such as, for example, hole-pin pairs (not shown) or slot-wedge pairs (not shown) provided within the contact region of the exclusion guards within the peripheral region 211 of the platen 200. Another such alignment means, which is illustrated in Figures 7-10 and 12, involves the use of flanges such as 404, which are spaced along the outside edge of the exclusion guards and extend down in such a manner as to engage the outside edge of the respective platens associated with the exclusion guards in Figures 7-10, 12, and 13 and compel alignment of the exclusion guards with the respective platens, hence with the wafer 402. The flange members 404 may be tapered as shown to engage progressively the outside edge of the respective platens. An additional alignment means is preferably utilized and includes alignment slot 710 and alignment hole 712 in Figure 7. Alignment slot 710 and alignment hole 712 are identical to alignment slot 906 and alignment hole 904 in Figure 9. Referring to Figure 7, guide blocks 718 and 720 with alignment pins 714 and 716, respectively, are fastened

to platen block 202 with any suitable fastener such as, for example, bolts 722 and 724, respectively, Guide blocks 718 and 720 also include spacers 726 and 728, respectively. The alignment slot 710 and alignment hole 712 in the exclusion guard 700 are mated with alignment pins 714 and 716. Alignment pins 714 and 716 are oriented to insure proper positioning of exclusion guard 700. All of the exclusion guards and platens include the alignment slot and hole and alignment pins, respectively.

Although physical restrictions to deposition control gas flow have been defined with reference to an exclusion guard extension and the frontside of a wafer in Figures 7-12, alternate and/or combination restrictions may be provided. For example, gas groove 210 in Figures 4-9 and 12 may be manufactured so that the opening of gas groove 210 at the surface of platen block 202 forms a restrictive opening to deposition control gas flow. Gas groove 210 may be manufactured to form a restrictive opening by, for example, force fitting an insert, made of a material having a thermal coefficient of expansion similar to the coefficient of expansion of the platen block, into gas groove 210 to form a continuous restrictive opening. The thickness of the insert is preferably ten times the width of the restrictive opening. When an alternate restriction is provided, the separation distance between the exclusion guard extension and the wafer frontside periphery may be increased. Additionally, when the restriction is placed near the edge of the wafer, the deposition control gas prevents deposition on the wafer backside and wholly or partially on the wafer edge.

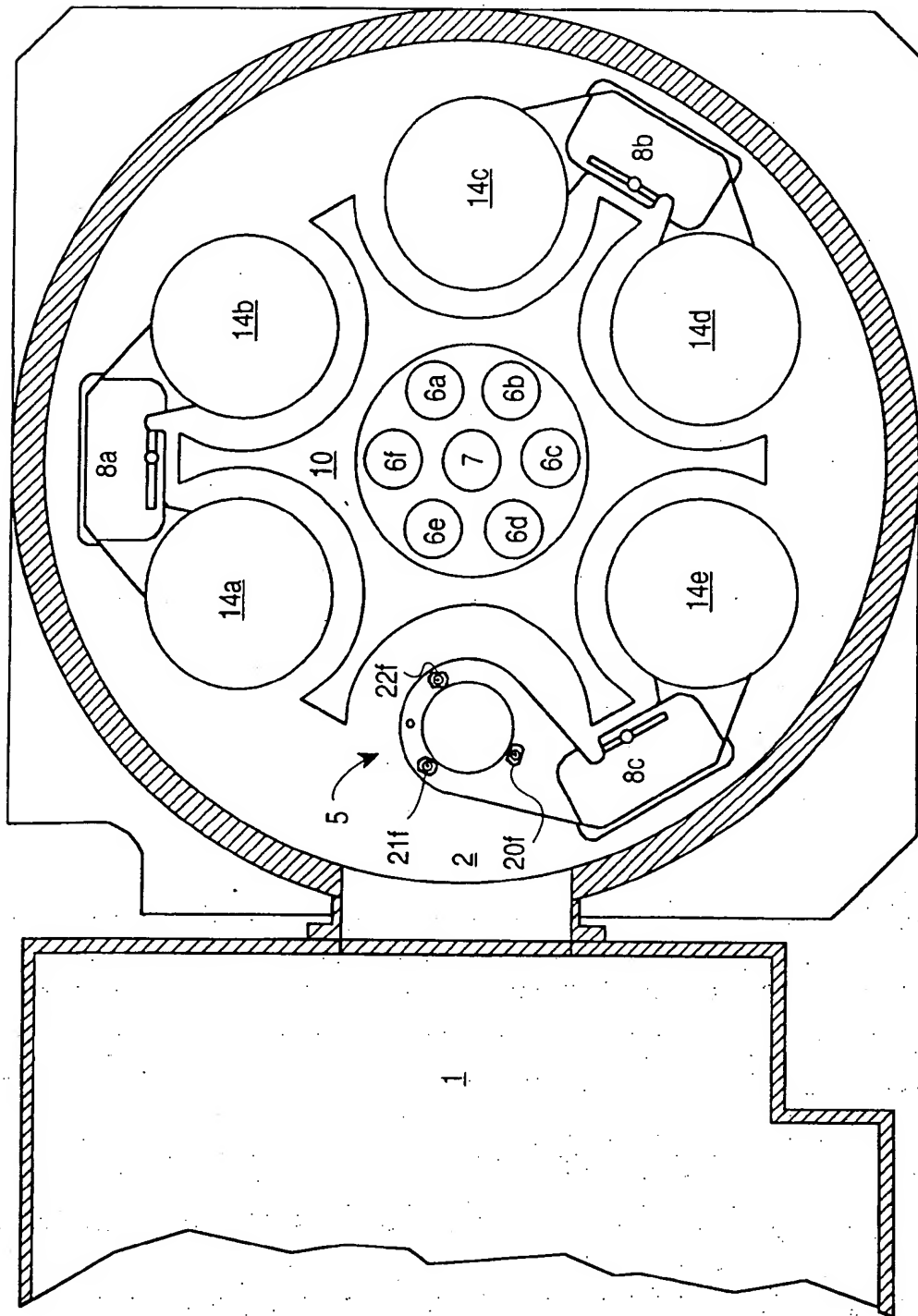
Wafer alignment at the load/unload station 5 is improved by substituting the centering station 1300 shown in Figure 13. Preferably, the centering station 1300 is water cooled to maintain dimensional consistency when handling hot wafers. A wafer is brought into the process chamber 2 on the loadlock transfer paddle (not shown). The paddle is driven so that the wafer contacts the two alignment pins 1302 and 1304, which preferably are sapphire. The paddle then is slightly overdriven by about 2mm to 4 mm, for example, so that the wafer registers against the pins 1302 and 1304 and moves backwards on the paddle. The paddle then is lowered, easing the wafer onto ceramic pads 1310, 1312 and 1314. Cutouts 1320 and 1322 are provided for clearance of the paddle. The paddle then is withdrawn from the process chamber 2. Holes 1330, 1332 and 1334 are provided for lift pins used in transferring wafers from and to the load/unload station 5. Accuracy of centering is better than  $\pm 0.1$  mm.

While our invention has been described with respect to the embodiments and variations set forth above, these embodiments and variations are illustrative and our invention is not to be considered limited in scope to these embodiments and variations. For example, the various shapes and dimensions and the various flow rates and pressures set forth herein are illustrative, and other shapes, dimensions, flow rates, and pressures may also be effective for the intended purpose. Also, features such as the platens, exclusion guards, gas grooves and lines,

and vacuum grooves and lines discussed herein may be changed to accommodate varying wafer sizes. Moreover, the deposition process discussed herein is illustrative, and other processes may also be effective for the intended purpose. Furthermore, while certain dimensions and locations of restrictive openings and deposition control gas composition have been described in conjunction with the various platens and exclusion guards, it will be appreciated that the dimensions and locations of restrictive openings and deposition control gas composition may be varied in order to obtain uniform deposition control gas flow around the periphery of a wafer and uniform material deposition on the frontside of the wafer. Moreover, in all exclusion guard and platen cases, an additional restrictive opening can be incorporated within the platen itself to achieve more uniform distribution of gas to all points at the wafer periphery. Accordingly, other embodiments and variations not described herein are to be considered within the scope of our invention as defined by the following claims.

#### Claims

1. An apparatus for supporting a substrate in a chemical vapor deposition process chamber, comprising:
  - a wafer-supporting body disposed in the process chamber;
  - an exclusion body disposed in the chamber in alignment with the support body, the exclusion body including a portion projecting over a frontside peripheral region of the wafer and uniformly spaced from the wafer frontside peripheral region to form a uniformly restrictive passage connecting a first volume of the chamber proximate the wafer frontside deposition surface to a second volume proximate the wafer edge;
    - wherein the first volume communicates with a source of process gas, and the second volume communicates with a source of deposition control gas.
2. The apparatus of claim 1 the restrictive passage is spaced as close to the wafer frontside periphery as wafer and thermal expansion tolerances permit.
3. The apparatus of claim 1 further comprising a venting region disposed in the exclusion body uniformly spaced from and encircling the exclusion body projecting portion, the venting region communicating with a source of venting gas for creating a venturi effect to draw the process gas toward the projecting portion when in place during wafer processing.
4. The apparatus of claim 3 wherein the venting region communicates with the second chamber, the venting gas being the same gas as the deposition control gas.
5. The apparatus of claim 4 wherein the exclusion body is a single piece in which the venting region comprises a plurality of orifices through the exclusion body.
6. The apparatus of claim 5 wherein the venting region contributes a reactant gas component to the first volume to improve deposition uniformity.
7. A method for chemical vapor deposition, comprising:
  - supporting a wafer on a supporting body disposed in the CVD chamber;
  - aligning an exclusion body disposed in the chamber with the support body;
  - uniformly spacing a projecting portion of the exclusion body from a frontside peripheral region of the wafer to form a restrictive passage connecting a first volume of the chamber proximate the wafer frontside deposition surface to a second volume proximate the wafer edge;
  - providing a process gas to the first volume;
  - and
  - providing a deposition control gas to the second volume at a pressure equal to or greater than the pressure of the process gas.
8. A method as in claim 7, wherein the restrictive passage is as small as wafer and thermal expansion tolerances permit.
9. A method as in claim 7 further comprising venting a gas uniformly around the first volume to create a venturi effect that draws the process gas toward the projecting portion during wafer processing.
10. A method as in claim 9 wherein the venting gas is the same gas as the deposition control gas.



**FIG. 1**

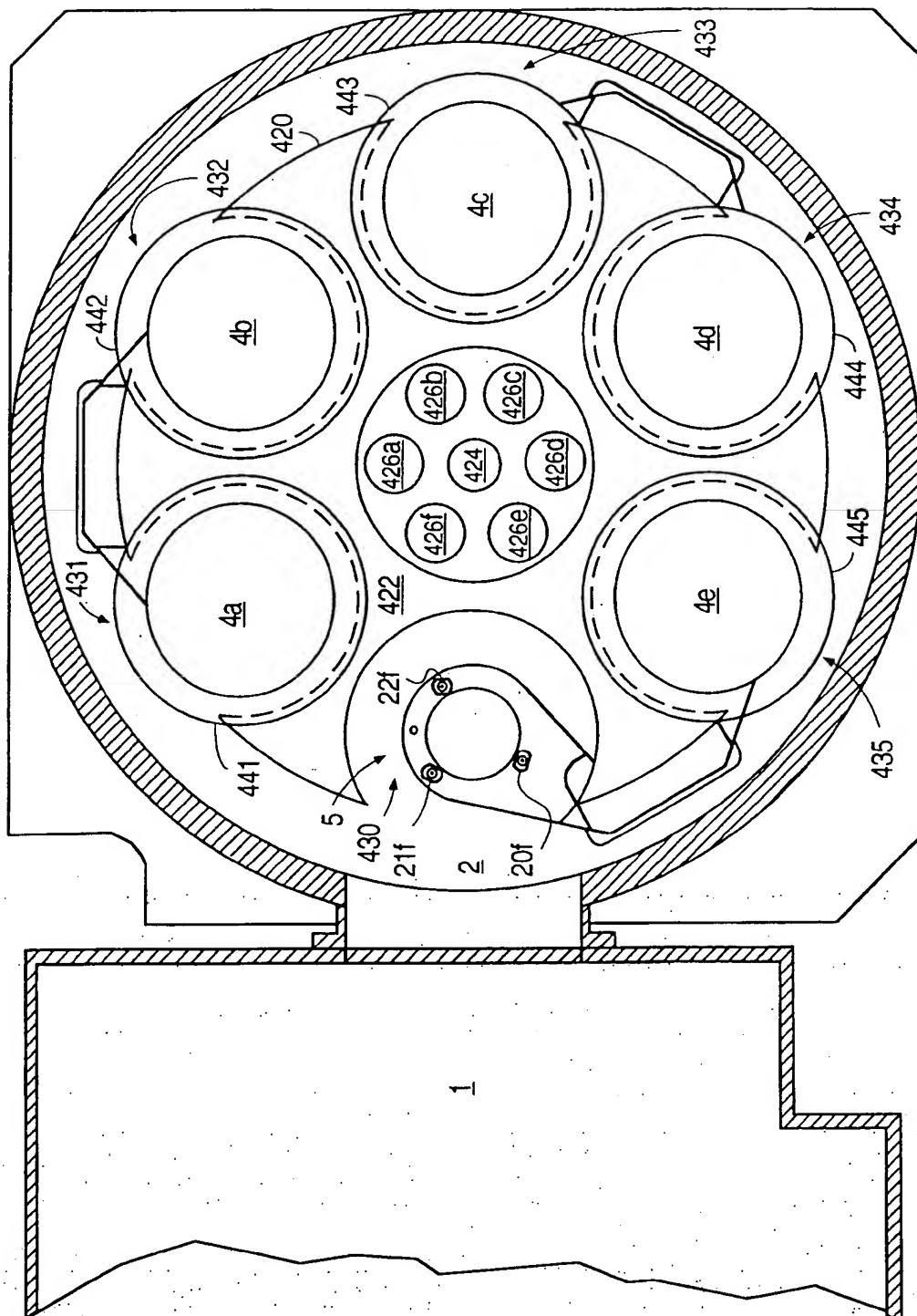


FIG. 2

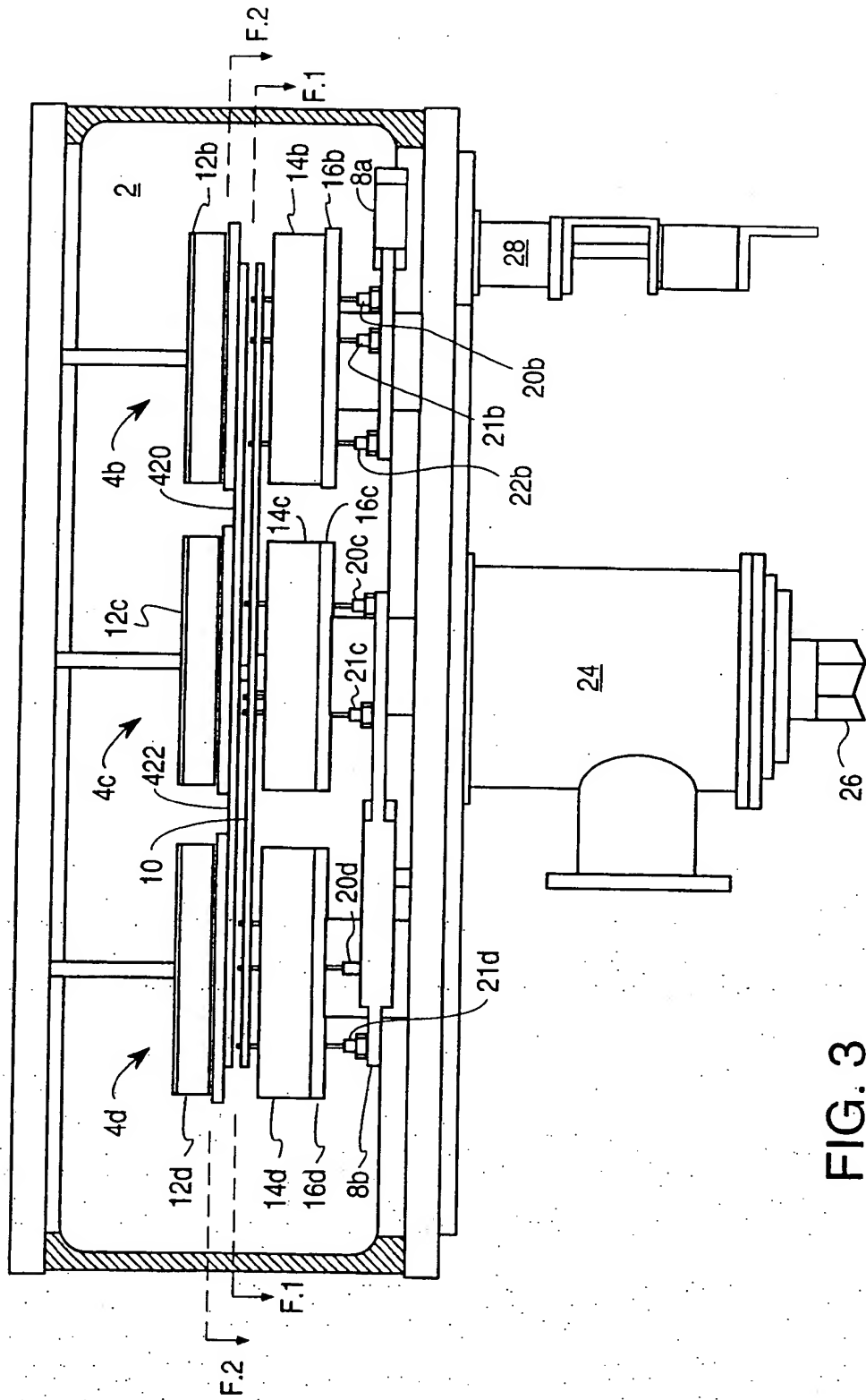


FIG. 3



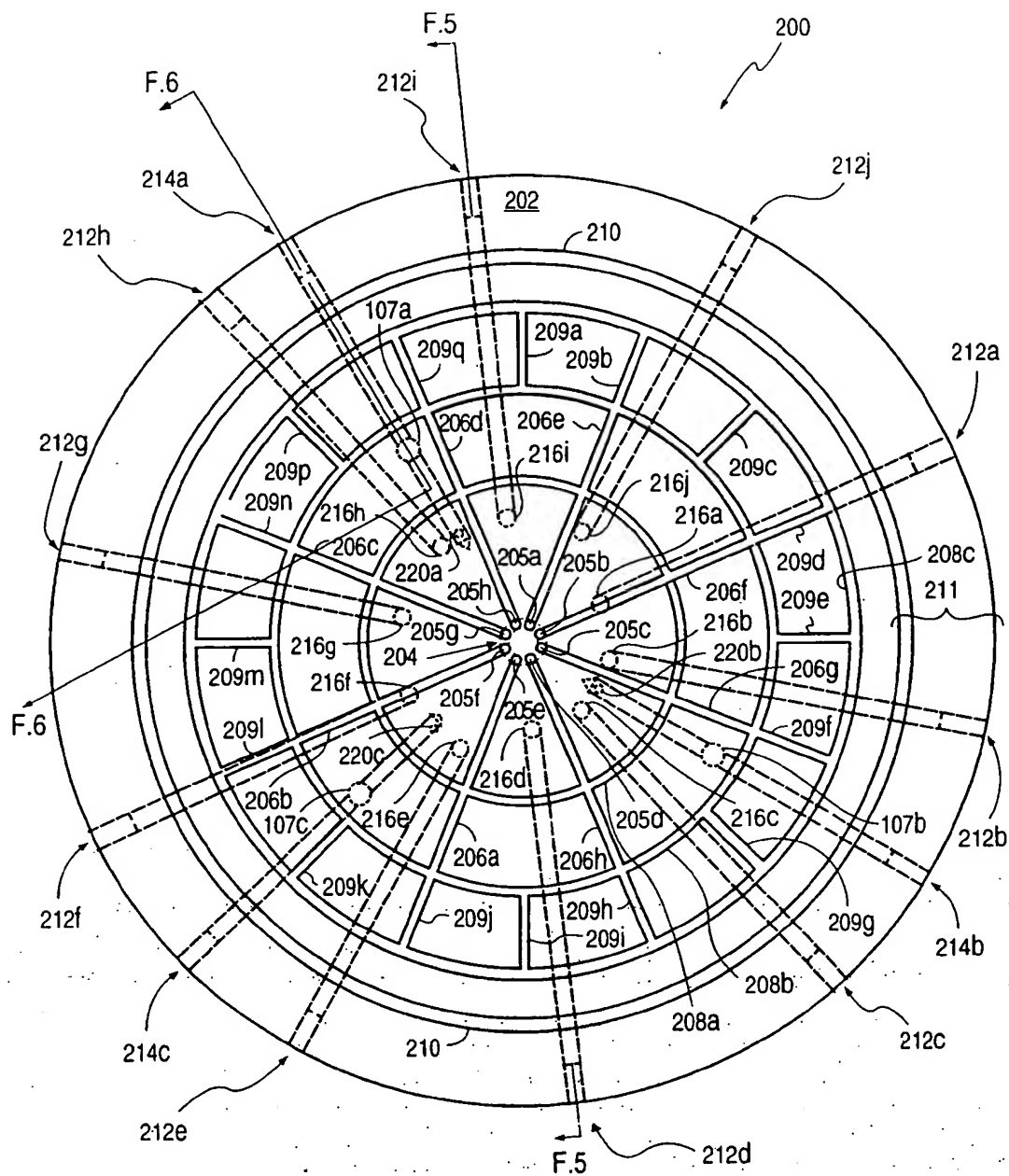


FIG. 4

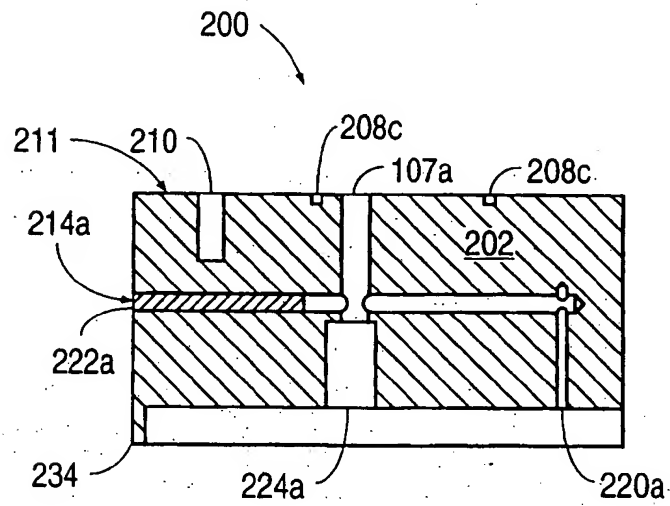
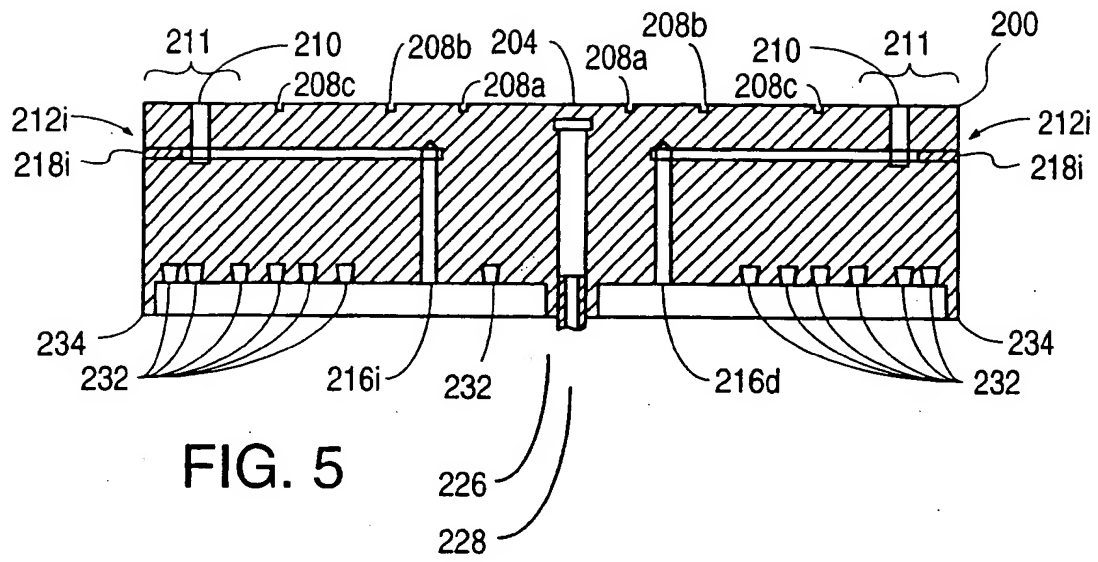


FIG. 6

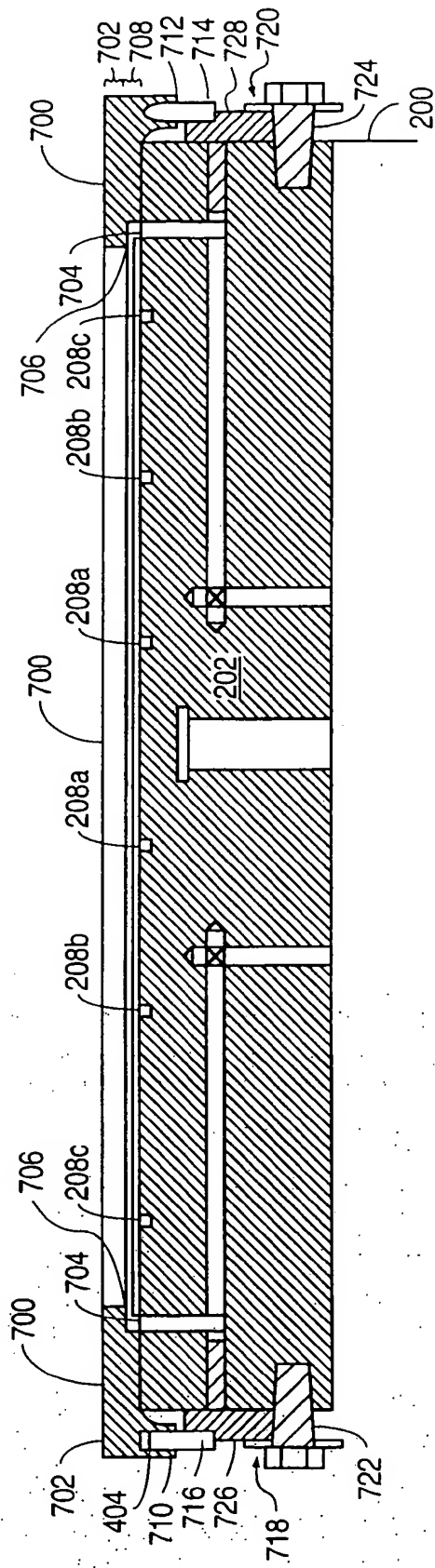


FIG. 7

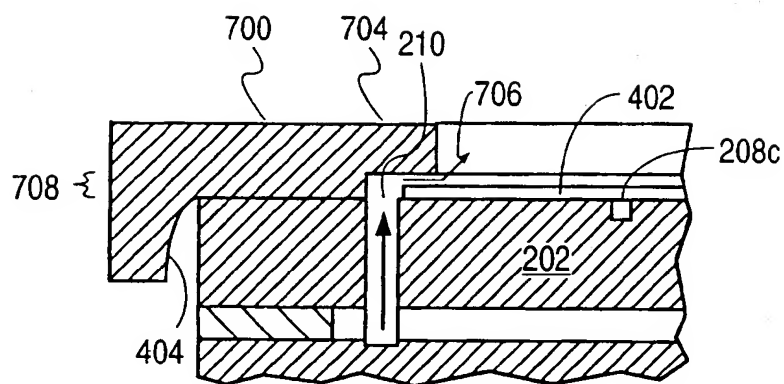


FIG. 8

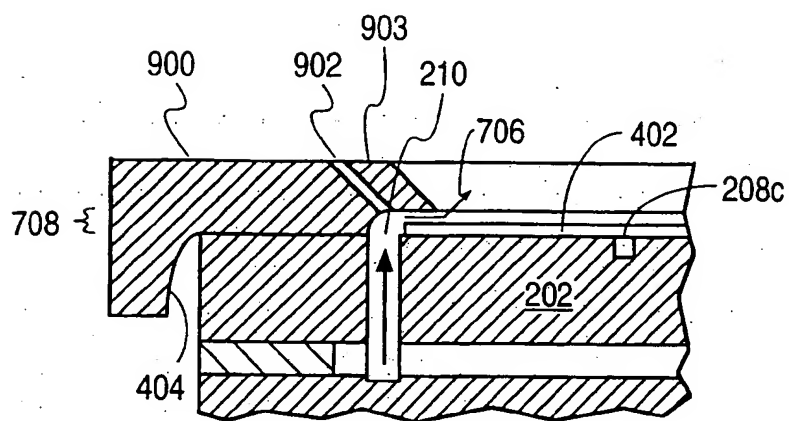


FIG. 9

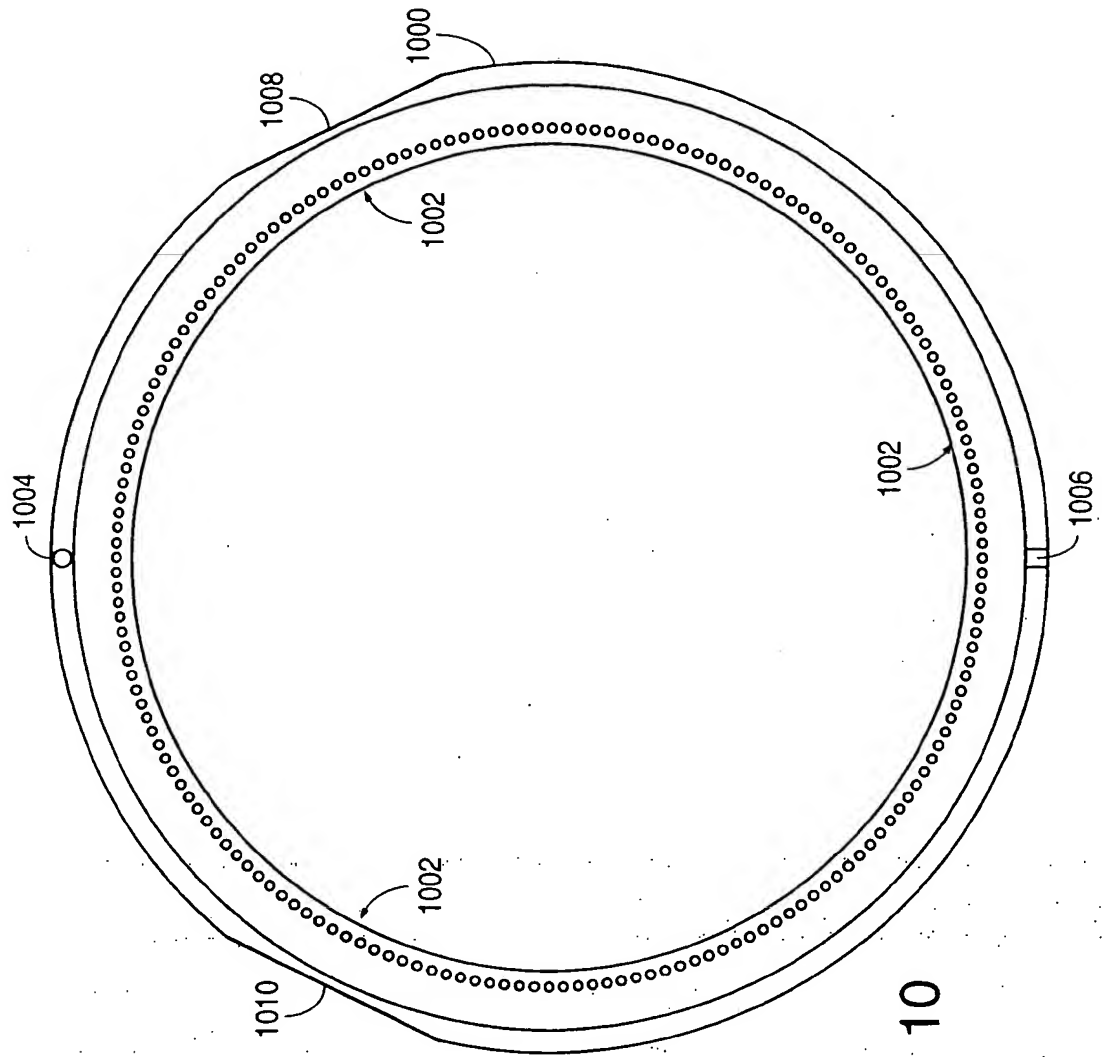


FIG. 10

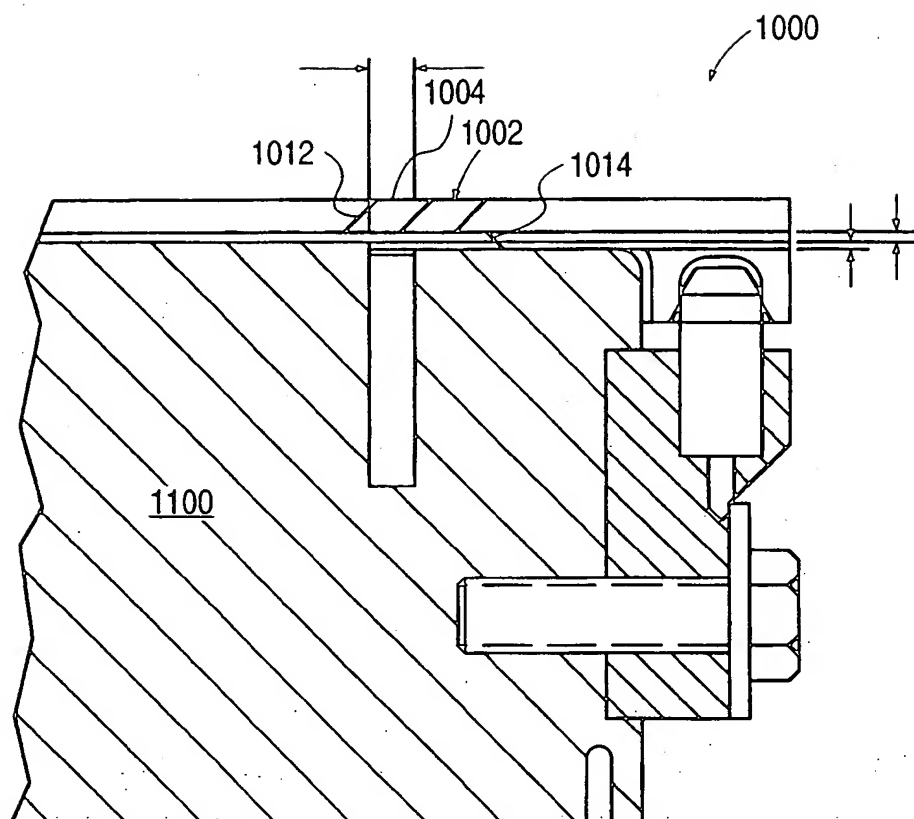


FIG. 11



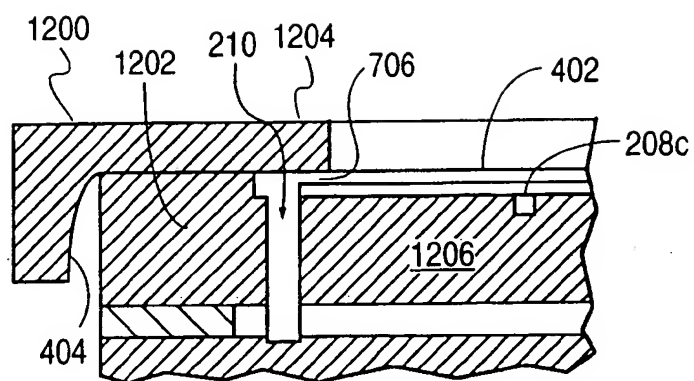
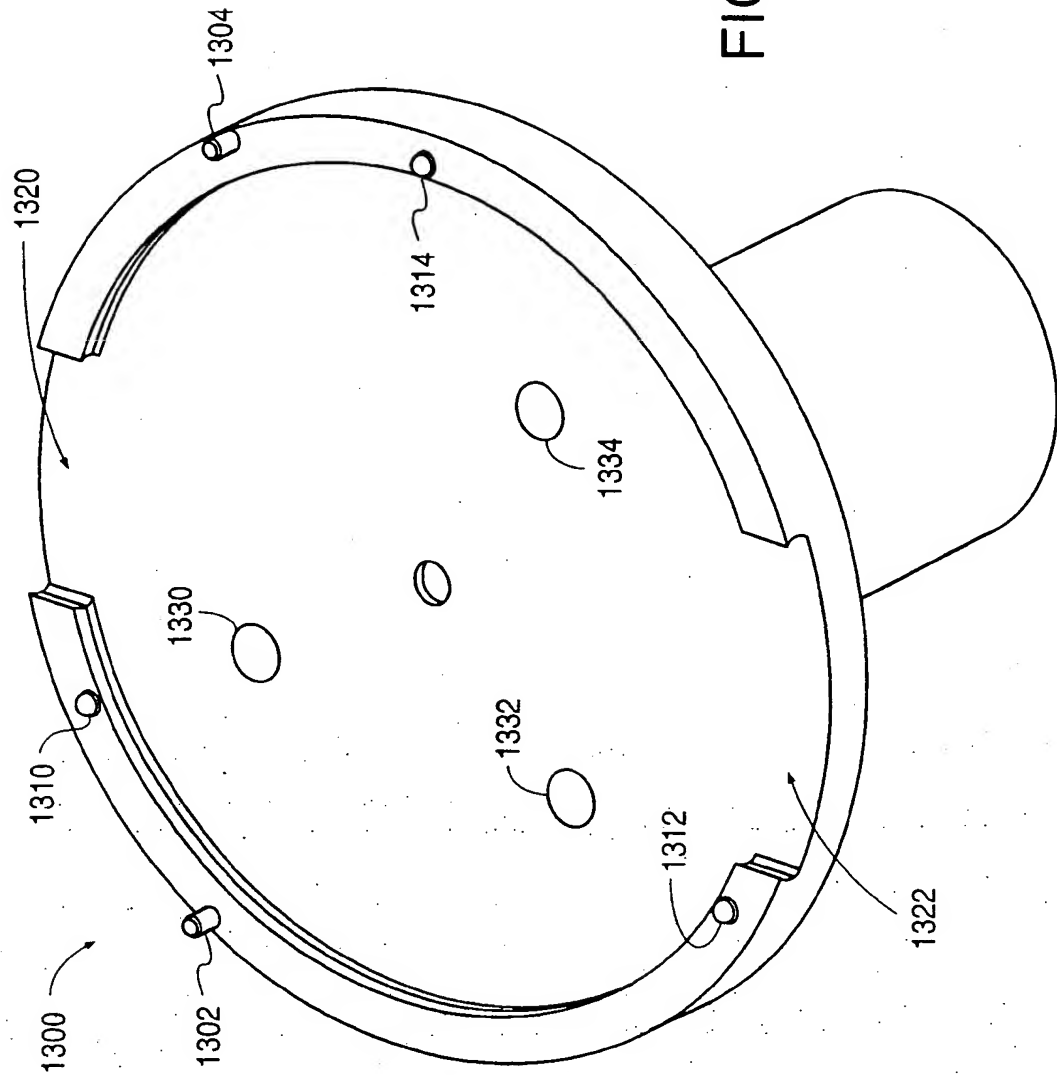


FIG. 12.

FIG. 13



(19)



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## (54) Chemical vapor deposition apparatus and method for exclusion of deposition and contamination from the backside and periphery of the wafers

(57) A platen supports a wafer during the deposition of tungsten, metal nitrides, other metals, and silicides in a chemical vapor deposition reactor. A deposition control gas that includes a suitable inert gas such as argon or a mixture of inert and reactant gases such as argon and hydrogen is introduced through a restrictive opening into an ambient in the reactor. An exclusion guard aligned with the platen has an extension (700) extending over a frontside peripheral region of the wafer. Dep-

osition control gas is introduced under the exclusion guard extension and exits through a restrictive opening (706) between the exclusion guard extension and a wafer frontside peripheral region. The restrictive opening provides a uniform pressure of deposition control gas at the edge and frontside of the wafer to prevent deposition on the wafer edge and backside.

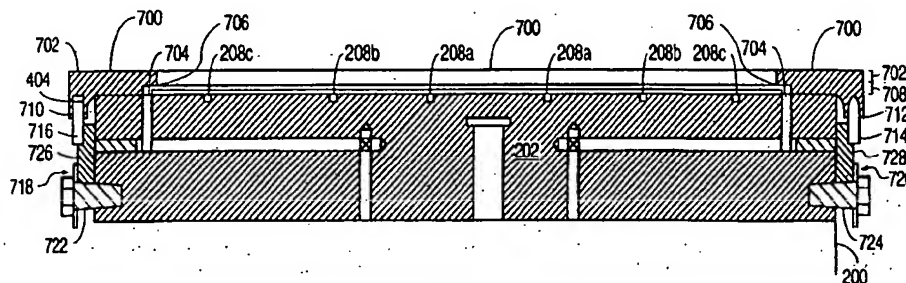


FIG. 7

EP 0 698 674 A3



European Patent  
Office

# EUROPEAN SEARCH REPORT

Application Number  
EP 95 11 2781

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	WO 93 13241 A (GENUS INC) 8 July 1993 * page 39, line 7 - page 42, line 12; figure 14 * * page 43, line 7 - line 10; figure 15 *	1,2,7,8	C23C16/44 H01L21/00 C23C16/04
P,X	EP 0 619 381 A (APPLIED MATERIALS INC) 12 October 1994 * column 7, line 21 - column 8, line 13; figure 6 *	1,7	
D,X	US 5 238 499 A (VAN DE VEN EVERHARDUS P ET AL) 24 August 1993 * column 8, line 45 - column 9, line 27 * * column 10, line 61 - column 11, line 17; figure 11 *	1,7	
E	US 5 574 247 A (NISHITANI EISUKE ET AL) 12 November 1996 * column 3, line 20 - line 62 * * column 11, line 1 - line 24; figures 8-10 *	1,7	
A	US 5 326 725 A (SHERSTINSKY SEMYON ET AL) 5 July 1994 * column 4, line 42 - column 5, line 30; figure 4 *	1,7	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int.Cl.6) C23C H01L
Place of search BERLIN		Date of completion of the search 12 August 1997	Examiner Le Minh, I
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